UNDERGROUND TRANSPORTATION IN THE RUHR COAL-MINING DISTRICT OF GERMANY

BY R. W. STAHL, H. E. SANFORD, AND J. B. BENSON

* * * * * * * * * **Information Circular 7547**

UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary
BUREAU OF MINES
James Boyd, Director

Work on manuscript completed September 1949. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Information Circular 7547."

January 1950

UNDERGROUND TRANSPORTATION IN THE RUHR COAL-MINING DISTRICT OF GERMANY

by

R. W. Stahl,[1] H. E. Sanford,[2] and J. B. Benson[3]

CONTENTS

	Page
Introduction	2
Hoisting	2
Roadways	3
Tracks and switches	3
Locomotives and cars	4
Clearance and shelter holes	5
Conveyors	6
Loading points and tipples	7
Haulage practice	8

ILLUSTRATIONS

Fig.		Follows page
1.	Hoists on opposite sides of shaft	2
2.	Hoisting engine room atop headframe	2
3.	Koepe system hoist	2
4.	Four-rope Koepe system hoist	2
5.	Typical mine cars	4
6.	Clearance along main roadways	4
7a.	Face conveyors	6
7b.	Face conveyors	6
8.	Use of both strands of belt for transportation	8
9.	Automatic cagers	8

---

[1] Mining engineer, Bureau of Mines, Wilkes-Barre, Pa.
[2] Mining engineer, Bureau of Mines, Mt. Hope, W. Va.
[3] Mining engineer, Bureau of Mines, Birmingham, Ala.

Information Circular 7547

INTRODUCTION

As movement or transportation of coal is second only in importance to actual mining, and as the latter is wholly dependent on the former, the efficiency of the haulage system often determines the efficiency of the entire plant. Safe or accident-free transportation is essential, also, because no attempt is made to divorce safety and efficiency, it being realized that they are inseparable.

Most of the Ruhr mines were opened decades ago, and many features that were considered up-to-date then are now obsolete. Progress in developing haulage systems has been slow, chiefly because it would be very costly to change many to accomodate more modern equipment. These systems are being altered or modernized slowly, as capital permits. The only revolutionary changes that have been made in mine haulage are the use of larger locomotives and cars, in the movement of shuttle cars, and in the adoption of skip hoisting. Most Ruhr shafts, however, will not accomodate large cars, the secondary roadways are too narrow for large locomotives, and the coal is too soft to permit skip hoisting because degradation would be too great. Therefore, notable advances have been made only at newer plants, where allowances have been made for modern equipment.

HOISTING

The shafts are deep (average 2,300 feet) and of comparatively small diameter. The small bore was designed to reduce costs of sinking and lining. Generally, the shafts are lined throughout with masonry; however, most of the buntons and guides are wooden.

The hoisting engines are installed in masonry structures, and where more than one hoist is used they are placed on opposite sides of the shaft to eliminate as much noise as possible (fig. 1). This arrangement also prevents an engineer from acting on any signals except those transmitted to him. A few hoisting engines are mounted in the headframes (fig. 2). The hoisting engines are equipped with overwind, overspeed, and auxiliary braking devices, which are tested frequently and kept operative at all times. The signal code is displayed in view of the engineer, and a light or dial indicator informs him of the cage's position in the shaft. Many hoists are equipped with recording devices, which show on a continuous chart the speed of hoisting as well as any delays throughout the 24-hour period.

A Koepe system of winding is in general use because of the depth of shafts (fig. 3). With this system, a single rope passes over a single-groove, large-diameter sheave attached to the motive power, and the ends of the rope, after passing over the head sheaves, are attached to the cages. A flat tail rope suspended in the shaft and connected to the bottom of the

Digitized by Google Original from THE OHIO STATE UNIVERSITY

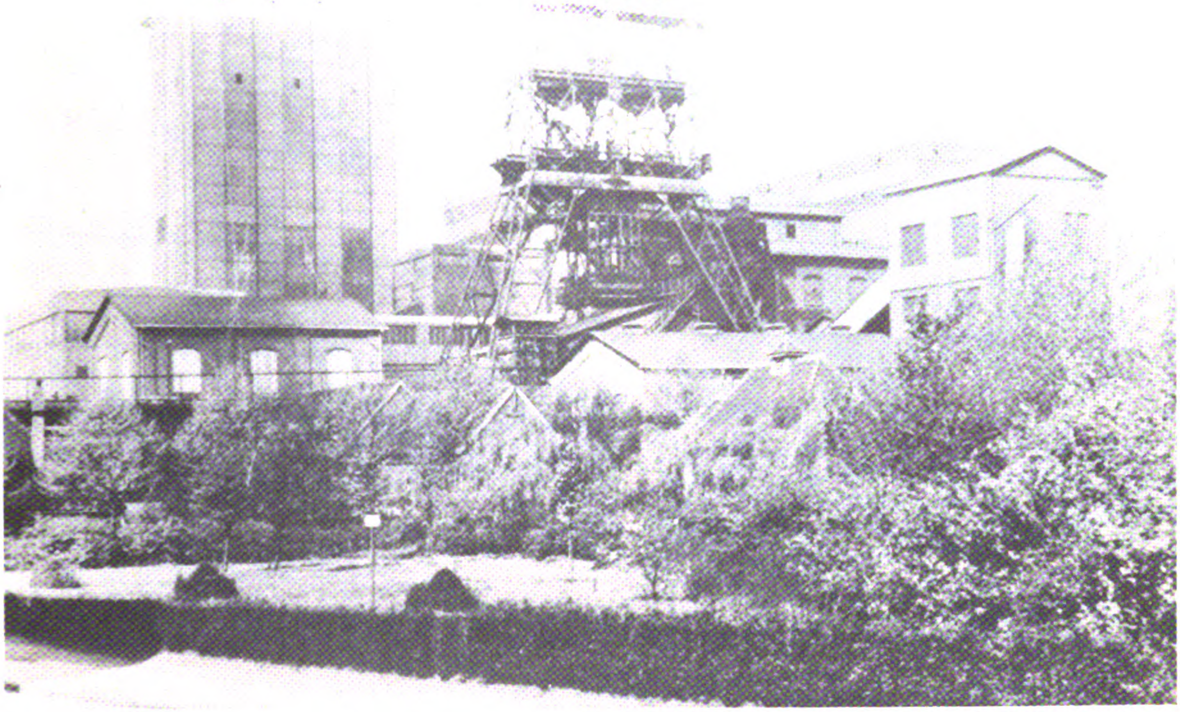

Figure I. - Hoists on opposite sides of shaft.

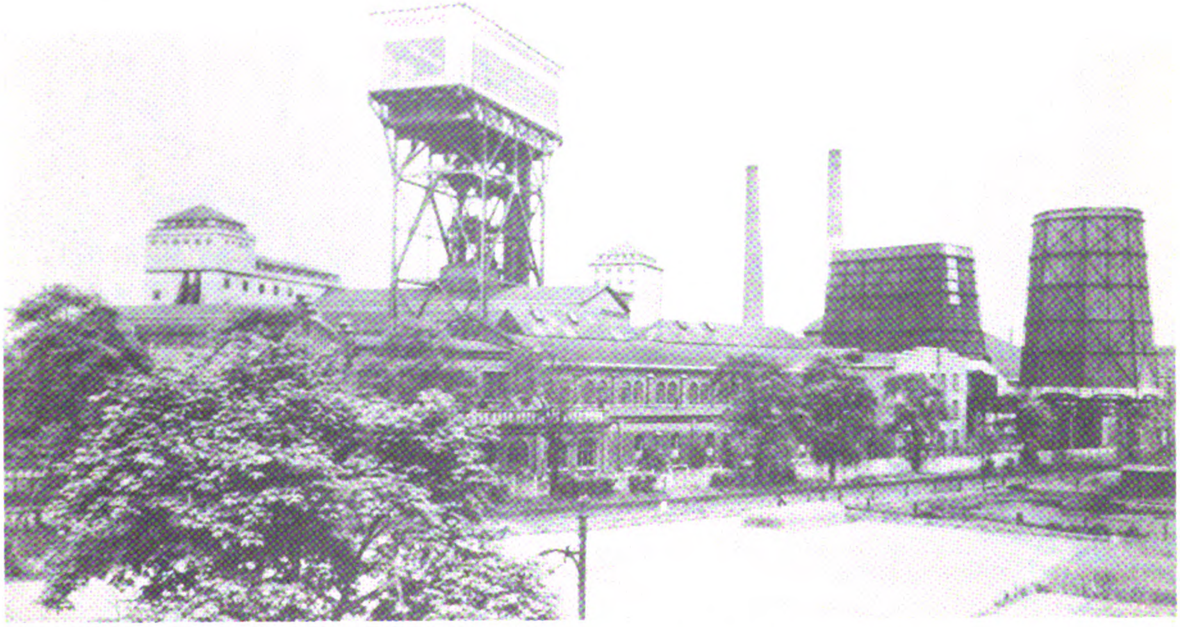

Figure 2. - Hoisting engine room atop headframe.

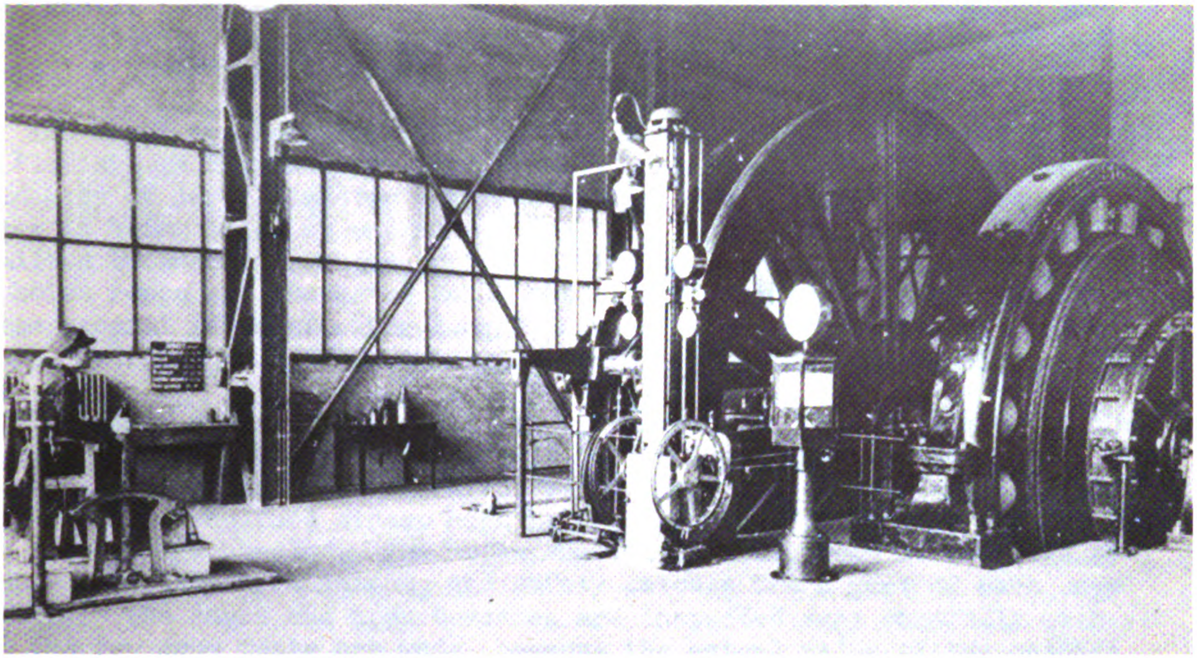

Figure 3. - Koepe system hoist showing single-groove, large-diameter sheave attached to motor shaft.

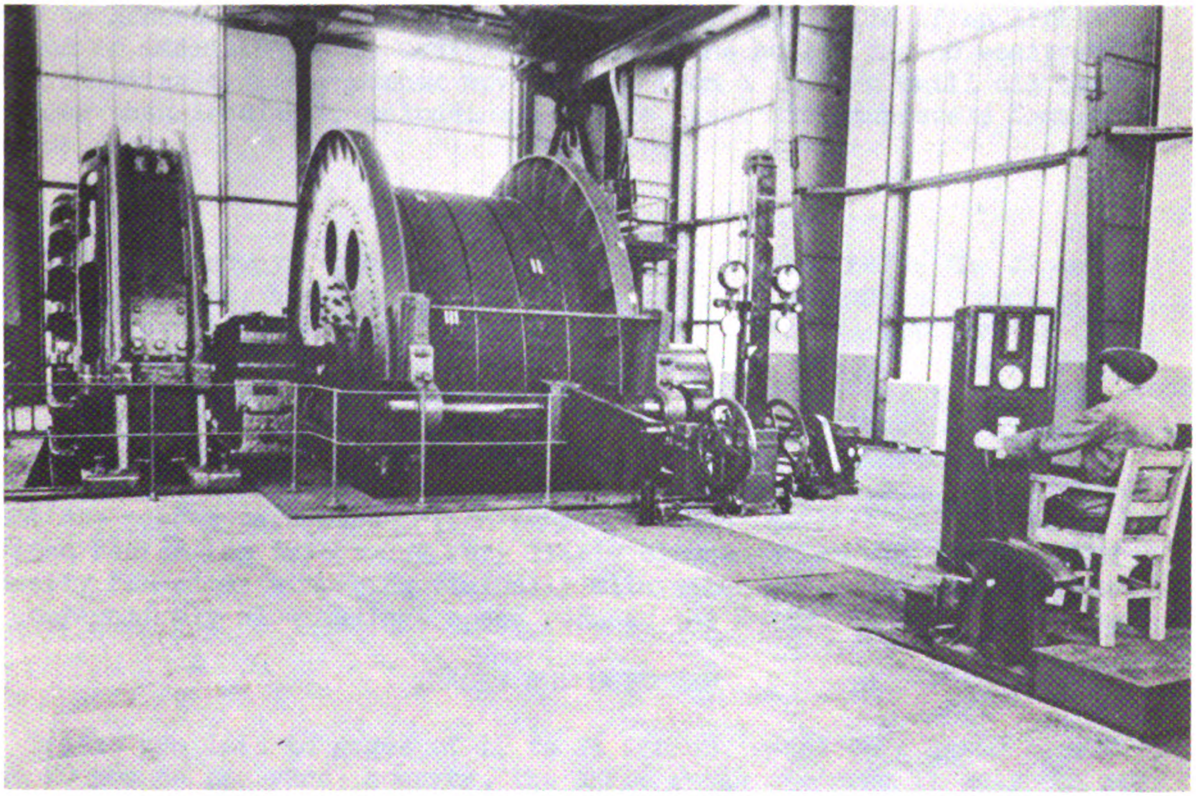

Figure 4. - Four-rope Koepe-system hoist mounted in headframe.

cages serves to balance the system. Both steam and electric engines are used to activate the hoisting system, and the engines are capable of moving at least a 50-percent overload.

The ropes are necessarily of large diameter (2-1/2 inches and greater), and flexibility decreases as rope diameter increases. To overcome the unwieldiness of large-diameter ropes as shafts become deeper, a four-rope system is being tried at one mine (fig. 4). In this system the load is equalized between four ropes, which permits much smaller ropes to be used. All hoist ropes are inspected daily and discarded after 2 years' service unless special permission for longer service is granted by the Mine Inspectorate, and then only after thorough visual and electromagnetic inspection.

The cages are multiple-deck, rigid, narrow type, although many of them are long enough to accomodate two cars in tandem. Cages contain 2 to 6 decks, and as many as 12 cars may be raised at one time. All cages are equipped with steel bonnets, enclosed sides, hand holds, and some form of end gate for use when persons are handled. The ropes are attached securely to the cage by a thimble and clamp arrangement, and safety catches are a part of each cage assembly. The cages and appurtenances are inspected very carefully each day, but few drop tests are made, because the actual value of the catches is questioned. All rope couplings and attachments have a large safety factor, and dependence is placed in this rather than the emergency device.

Cagers are employed at each shaft landing where materials or men are handled, and the cagers have complete charge of operations. The signal system is generally a bell actuated electrically, but quite often lights are used in addition to the audible signals. The hoists are so equipped that a hoisting engineer cannot move a cage from a landing until all decks are clear when loading or unloading may take place simultaneously from more than one deck.

ROADWAYS

The main roadways usually are driven through rock, hence the floor or base is solid rock; however, mining in the vicinity sometimes causes pressures that result in heaving of the floor, but in general the base is firm. The roadways are usually inclined 1 percent or less toward the shaft in order to favor movement of loaded trips to the shaft and to expedite drainage to a central sump somewhere near the shaft. A drainage ditch is provided along one side of most roads, and the water is confined to the channel; hence, haulageway drainage is generally good. During former development the passageways were driven narrow, no unrestricted walkway being provided beside the tracks and very little clearance between tracks. The necessity for close timbering virtually eliminates space for shelter holes, but comparatively slow haulage speed reduces the hazard to foot travelers.

TRACKS AND SWITCHES

Tracks are laid to gages of 18 to 28 inches, rails ranging in size from 20 to 70 pounds per yard; however, the large rails are used at only the more recently opened mines, where provision has been made to use heavier rolling stock, such as 3-1/2-ton cars and possibly 20-ton locomotives. The rails

Digitized by Google Original from THE OHIO STATE UNIVERSITY

are either welded together or securely fastened with angle bars or fishplates, and they are generally attached to wooden sills with tie plates and bolts. A few steel ties were noted, and occasionally sections of track were assembled at some central point and then transported intact to the place required. Usually, the rail joints are opposite each other instead of staggered, as is the practice in the United States, and kinks due to joint shifting were not uncommon. Gage spacers or rail braces were used when available, and where electric haulage was employed one rail of nonwelded track was bonded. Cross bonds are not customarily used.

The switches were generally assembled complete at some central point and transported as a unit to the required place, where a minimum of time was then needed to make the installation. Quite often the latches were moved by remote-control apparatus actuated by compressed air, but the hand-operated ones were equipped with levers that were not always parallel. Guard rails were installed as a part of each switch, and quite often these were extended some distance from the switch, especially around curves at turn-outs and junctions. Retrackers were placed in the track at some point near the switches, as it was a common practice to pull derailed cars to a switch or rerailer before attempting to retrack them.

In general, the tracks were maintained in good condition when materials were available for replacement and repair, but the drastic post-war shortages seriously curtailed the repair program.

LOCOMOTIVES AND CARS

Electric, Diesel, compressed-air, and storage-battery locomotives are in common use throughout the region, and numerous sizes are found, although a locomotive heavier than 10 tons is seldom seen, and the 5-ton type is more common. Most mine operators are enthusiastic about electric haulage and favor a trolley locomotive for main-line service and the storage-battery type for gathering service; however, mine regulations prohibit the use of electricity in any air current when the methane content exceeds 0.3 percent, thus limiting trolley haulage to intake airways in a few mines. The Diesel locomotive is objectionable because of the fumes emitted, which, even though not dangerous, are offensive and pollute the atmosphere of the area in which the locomotive is used. The compressed-air locomotive is the most expensive to operate, although the safest from a gas or coal-dust ignition standpoint, and therefore its use is advocated by persons who think only of safety.

Electric locomotives are equipped with pantograph-type trolley contacts, motors, and control apparatus approved by the Mine Inspectorate and cabs to protect the operator.

Diesel locomotives are generally 4-cylinder engines equipped with flame arrestors and exhaust-gas filters, and maintenance was as good as could be expected with the small supply of repair parts. Frequent tests were made to ascertain the quality of the atmosphere containing exhaust gases from the Diesels, and a trace of carbon monoxide sufficed to have a locomotive removed from service. Some tests conducted for the benefit of the authors revealed a lack of poisonous gases but the presence of aldehydes, which, although not

Original from THE OHIO STATE UNIVERSITY

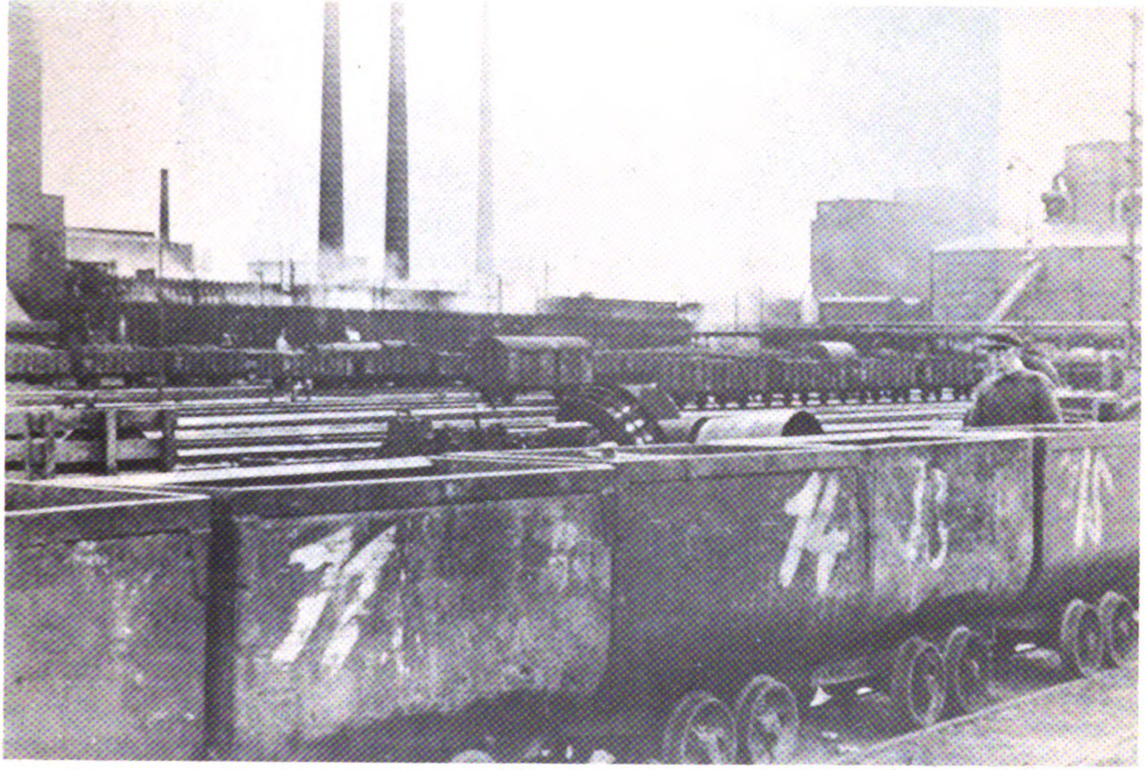

Figure 5. - Typical mine cars.

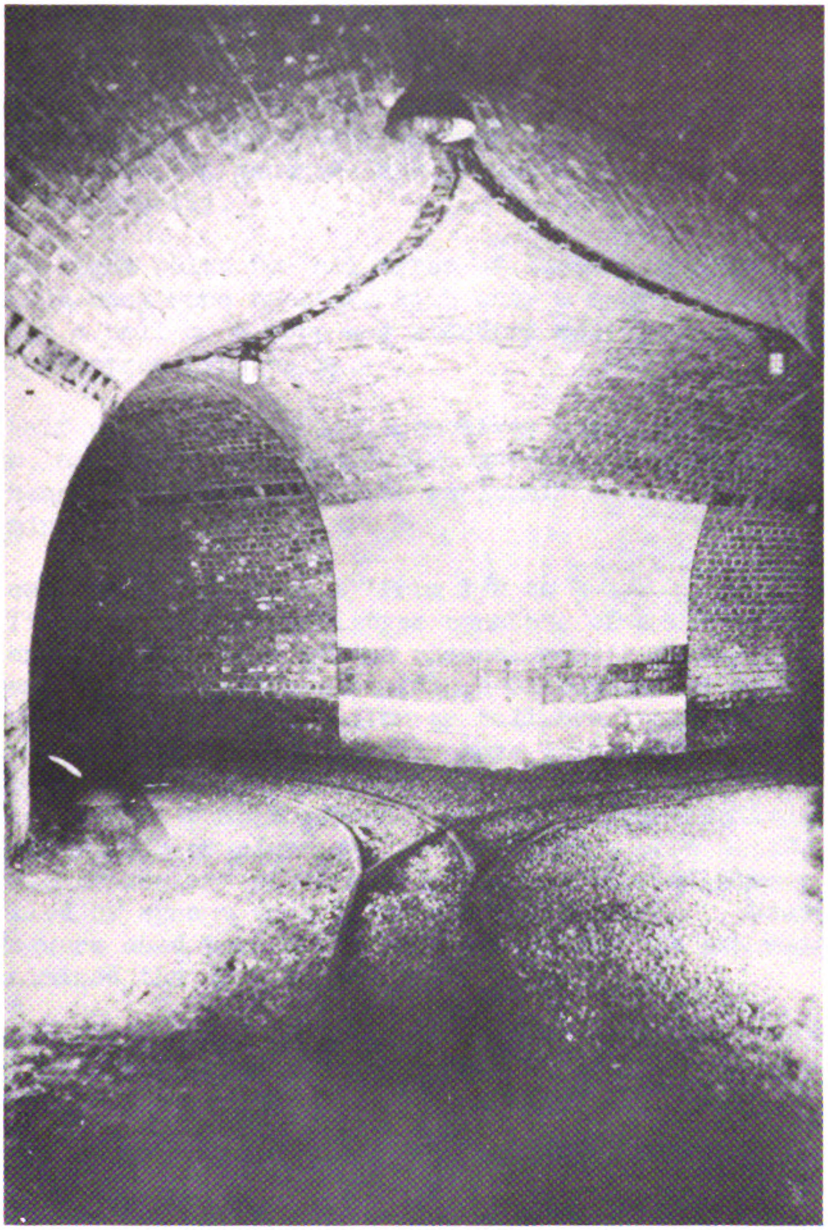

Figure 6. - Adequate clearance alongside main haulage tracks.

harmful in small quantities, have an adverse effect upon the membranes of the eyes, nose, and throat and cause an aggravating irritation when exposure is extensive.

The compressed-air locomotives are equipped with multiple-cylinder air reservoirs and the necessary pressure gages. The lights were electric, receiving power from individual compressed-air generators in the base of each lamp.

Storage-battery locomotives were very similar to the permissible types used in the United States, and those examined were equipped with all the necessary appurtenances. A general lack of batteries caused many locomotives to be discarded temporarily.

The lack of light bulbs for all types of locomotives was general throughout the field, and many were operated with only a miner's hand lamp for illumination. Either a bell or a horn was standard equipment on locomotives to warn travelers of approaching trips.

At least half of all available locomotives were out of service for lack of repair parts, and these were generally stripped in order to keep others in operation; hence, transportation was seriously hampered by lack of motive power at some mines.

The mine cars range in capacity from 1/2 to 3-1/2 tons and are all-steel construction (fig. 5). The general type consists of a U-section body-welded to end plates and fastened to a welded channel member frame. The axles extend through the frame and are fastened rigidly. Cast-steel spoke-type wheels of small diameter are equipped with roller or ball bearings, the roller type predominating. The bumpers are generally mere thin metal plates, which permit the car ends to virtually touch and introduce a serious hazard to anyone who may be between cars that bump together. Link-and-hook couplings are common, although a few automatic couplers and spring bumpers were noted on the new-type large cars. Brakes are not installed on any type of mine car, and motion must be controlled by sprags or similar makeshift devices. Occasionally, slides or skids were used to control trip speed, but the generally level haulageways minimized the need for these.

Many cars were abandoned for lack of repairs, and at least 25 percent of those in use were defective in some part, but continued use was mandatory if production was to be sustained.

CLEARANCE AND SHELTER HOLES

Ample clearance was maintained alongside main haulage tracks in most of the mines (fig. 6). However, the clearance between tracks in multiple-track haulageways and in gate roads was generally inadequate.

Most of the main haulageways were driven at least 20 feet wide to provide sufficient cross-section area for ventilation; thus, in double-track entries the clearance was generally 6 feet or more, and walkways with handrails were sometimes constructed.

Because of the comparatively short life of the gate roads, these entries were usually made very narrow, frequently not more than 6 feet inside the rib-and-roof-support lines; and when unusual pressures caused distortion of the supports, the clearance was sometimes barely sufficient to permit passage of the haulage equipment.

The clearance along conveyor lines in entries was usually sufficient, but this was not true along conveyor lines in working places (figs. 7a and 7b). In the first place, posts in working places were usually set as close as possible to each side of the conveyors; in the second place, conveyors were kept as near the coal face as possible; and, because of the proximity of the breakline of caving, all materials were kept as near the coal faces as possible. Consequently, persons traveling along a face were compelled to squeeze between posts, climb over stored materials, or ride on the loaded conveyors.

Shelter holes, as such, were virtually nonexistent in the Ruhr, although a few were provided in some mines. The generally wide clearance along main haulageways reduced the need there for shelter holes, and the system of supporting the roof and sides of gate roads made the construction of shelter holes impracticable if not impossible. In most cases the steel arches or the legs of timber sets were virtually "skin to skin", and the space behind the timbering was lagged and then packed with broken stones. The omission of enough rib support to provide shelter holes along gate roads would increase rather than decrease a haulage hazard.

CONVEYORS

Only at the faces of a few of the gate roads is the coal hand-loaded directly into mine cars. At all other places, the coal either flows by gravity or is transported by conveyors and spiral chutes to the loading points. Except at the face of a few gate roads, face and intermediate transportation in the Ruhr mines is generally performed by conveyors and spiral or gravity chutes. At the present time (1948), approximately 475 miles of conveyors are in use in face regions, 300 miles being used on the longwall faces and 175 miles in the gate roads. Virtually every type of conveyor is used, but shaking and belt conveyors predominate. The type of conveyor used on the longwall faces is generally controlled by the pitch of the coal bed. Belt and shaking conveyors were generally used in the relatively flat beds, whereas chain-and-flight, pan, or chain-and-button retarding conveyors were used in the semisteep and steeply pitching beds. In many instances, however, where flat, semisteep, and steeply pitching conditions existed on the same face, two or more types of conveyors were employed. The general practice in steeply pitching beds, where the faces were advanced at an inclination to form an angle of repose for the packing material, the coal flowed by gravity on top of the packing material to the gate roads. In some instances, metal chutes were employed to facilitate gravity flow. Where coal plows or other mechanical loading means were employed, chain-and-flight conveyors generally were used.

The conveyors used in gate roads were either belt or pan type. Frequently both types were used in the gate roads. Conveyors, whether on the faces or in the gate roads, seldom exceeded 300 feet in length; however, a few belt conveyors were as much as 1,200 feet in length. Most conveyors were operated by compressed-air motors of 5 to 50 horsepower. A few conveyors were operated by

Original from THE OHIO STATE UNIVERSITY

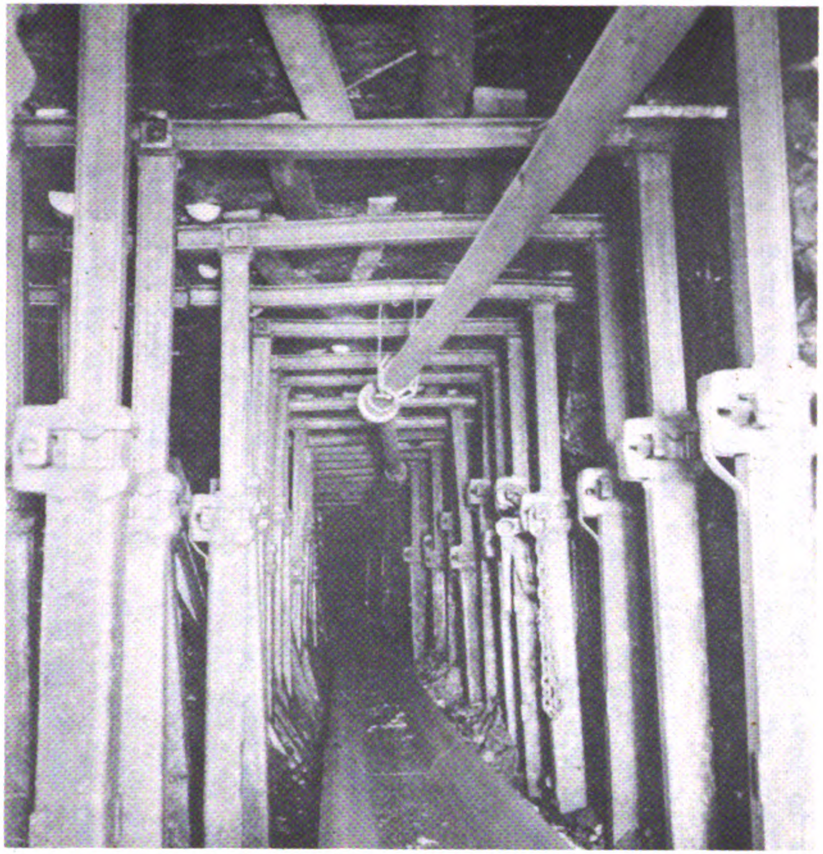

Figure 7a. - Face conveyor on section of face supported by steel.

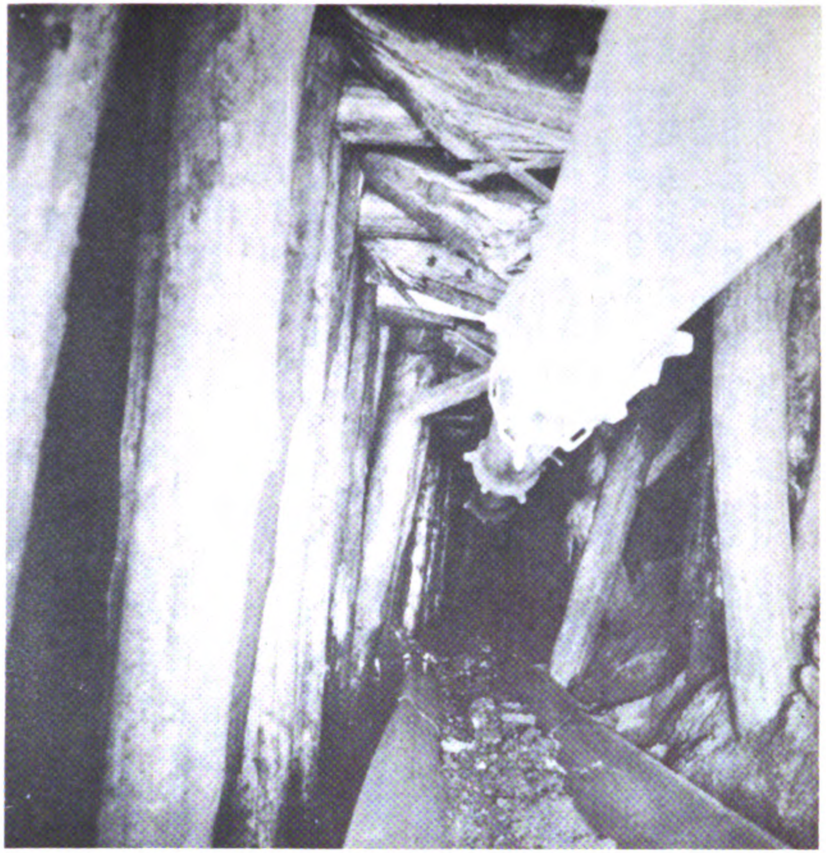

Figure 7b. - Face conveyor on section of same face supported by wood.

approved-type electric motors. Many of the shaking conveyors, especially those that exceeded 200 feet in length, had auxiliary drives near their center or rear end. A few of the pan, flight, and retarding conveyors also were equipped with drives at each end. Shaker, pan, and flight conveyors were 18 to 24 inches wide and belt conveyors 15 to 40 inches. Virtually all of the conveyors were in a bad state of repair because of age and wear. Pans were badly worn, and many cradles and rollers were missing. Many of the conveyor belts were so badly worn that they were only about half their original width. Breakdowns and failures were common, and repair parts were difficult to obtain because of the shortage of steel. However, the electric drives and controls were maintained in approved condition.

A few of the gate-road belt conveyors were so installed that the coal was transported on the bottom strand. In such instances, the top or return strand was used for transporting supplies to the face, because most of these conveyors were not reversible (fig. 8).

The gate road conveyors discharged the coal directly into mine cars or spiral chutes. The spiral chutes in staple shafts, in addition to serving as a means for conveying the coal from one level to another, frequently served as storage bins. Spiral chutes were 40 to 60 inches in diameter and as much as 800 feet in length. Some spiral chutes had capacities up to 400 tons of coal an hour, and those made of manganese steel had a life expectancy seven times greater than those made of ordinary steel.

LOADING POINTS AND TIPPLES

Loading points underground in the Ruhr district were of wide variety of styles and capacities. Some were intended to handle the coal from a single short face, whereas others handled the coal from two or more faces.

The shorter faces generally were in the steeper formations, where coal either gravitated or was retarded to the loading points in comparatively small quantities. In such cases the general practice was to construct a lightweight bulkhead at the loading point and to load the mine cars by means of a chute between the bulkhead and the cars. Such a loading point was advanced as the faces advanced; therefore, all the equipment was constructed so as to be moved readily by a few men.

In the flatter workings, coal was usually dumped into mine cars from a belt conveyor regardless of the types of conveyor used along the face. Here, again, the loading-point equipment was constructed so that it could be advanced with a minimum of labor.

Some of the loading points for mother belts or gate-road conveyors were installed semipermanently to handle several hundred tons of coal a day for several years. In this case, the conveyors generally discharged into bins, from which the coal was fed into mine cars.

Depending on the quantity of coal to be handled, mine cars at the loading points were shifted by hand or mechanically. Tail tracks and switches were not used at places where the loading points were advanced with the face.

Original from THE OHIO STATE UNIVERSITY

Instead, double tracks were maintained to the loading point, and cars were switched manually from one track to the other on the sheet-iron-covered floor. At places where the loading point served a long face producing a larger volume of coal, the car-changing process sometimes required the services of several men.

Trip feeders of various types were nearly always used at loading points that handled a large volume of coal. Generally they were operated by compressed-air-driven motors, although a few electric motors were used.

Another device at some of the more important loading points was used to compact coal in the mine cars. This device usually consisted of a bar about 4 by 4 inches in cross section and slightly shorter than a mine car. The bar was held by springs against the side of a mine car being loaded and was subjected to comparatively light blows from a jackhammerlike device operated at high speed.

A tippling device was nearly always used in the upper gate roads of places where stowing was done. Most of these were small, portable, rotary dumps that could be operated easily by two men. It was not unusual for 200 cars of back-fill material to be dumped by means of such a tippler in 24 hours.

HAULAGE PRACTICES

Rules governing transportation have been formulated for every mine to supplement the provisions of the Mining Code, and excerpts or pertinent parts of these are conspicuously displayed at important points where employees concerned are most likely to see them. Placards denoting special hazards or dangerous practices are always in evidence at points where chances are likely to be taken or extra precaution is necessary. Thus, a definite attempt, through advertising, has been made to eliminate mining's second greatest killer.

One very dangerous practice, which has been recognized as such for years, was quite evident in several mines visited, viz., locomotive operators leaving moving locomotive to throw switches. Steps have been taken to end this practice such as the installation of a remote-control switch mechanism that can be operated from the locomotive or central switching stations with an operator to control switching; however, lack of a brakeman as well as carelessness or thoughtlessness have tended to perpetuate the practice.

The speed of trips is regulated by law to 10 miles per hour, and no violations of this rule were noted.

The lack of car brakes has encouraged the use of insecure, makeshift retarding and holding devices such as chips and pieces of rock or coal. In many mines, prepared sprags are afforded at regular car-shifting or storage places, but in general these are seldom available when needed.

Retrackers and lifting jacks are not standard equipment on locomotives as they are in the United States, but all derailed equipment is hauled to a retracking device in the track or near a switch.

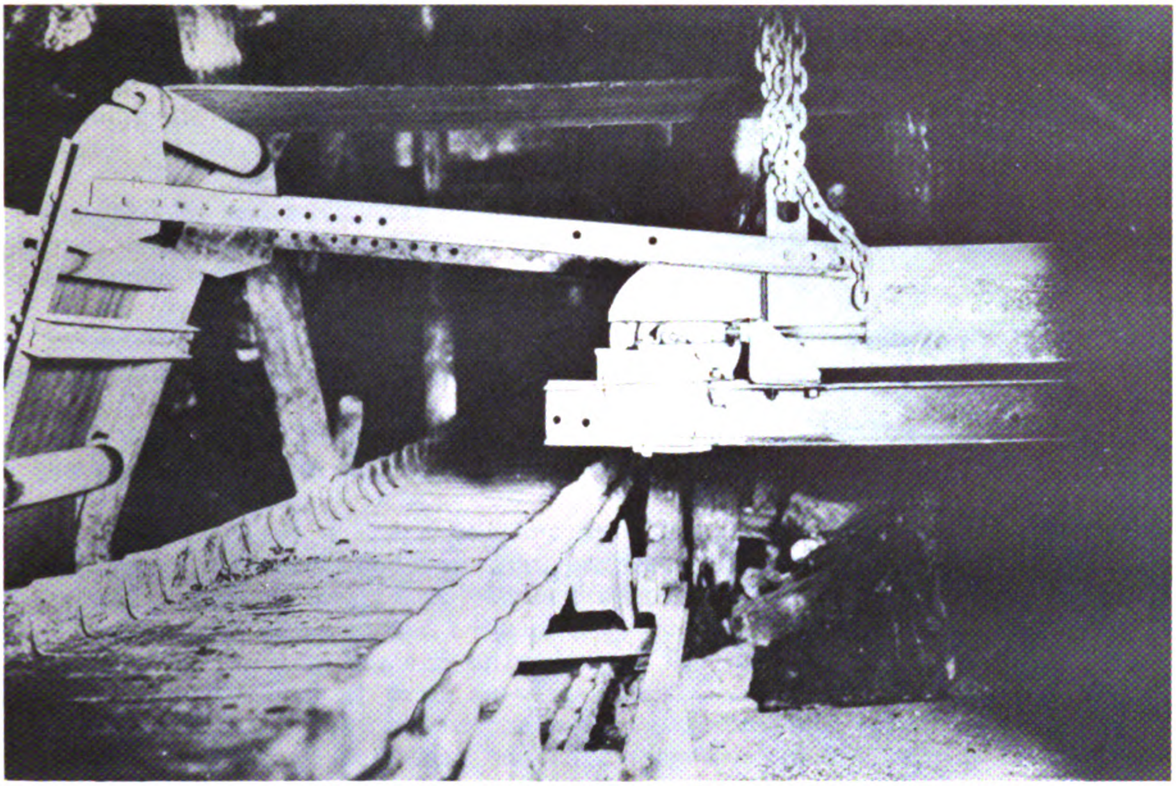

Figure 8. - Coal transported on bottom strand and supplies transported on top strand of gate road belt conveyor.

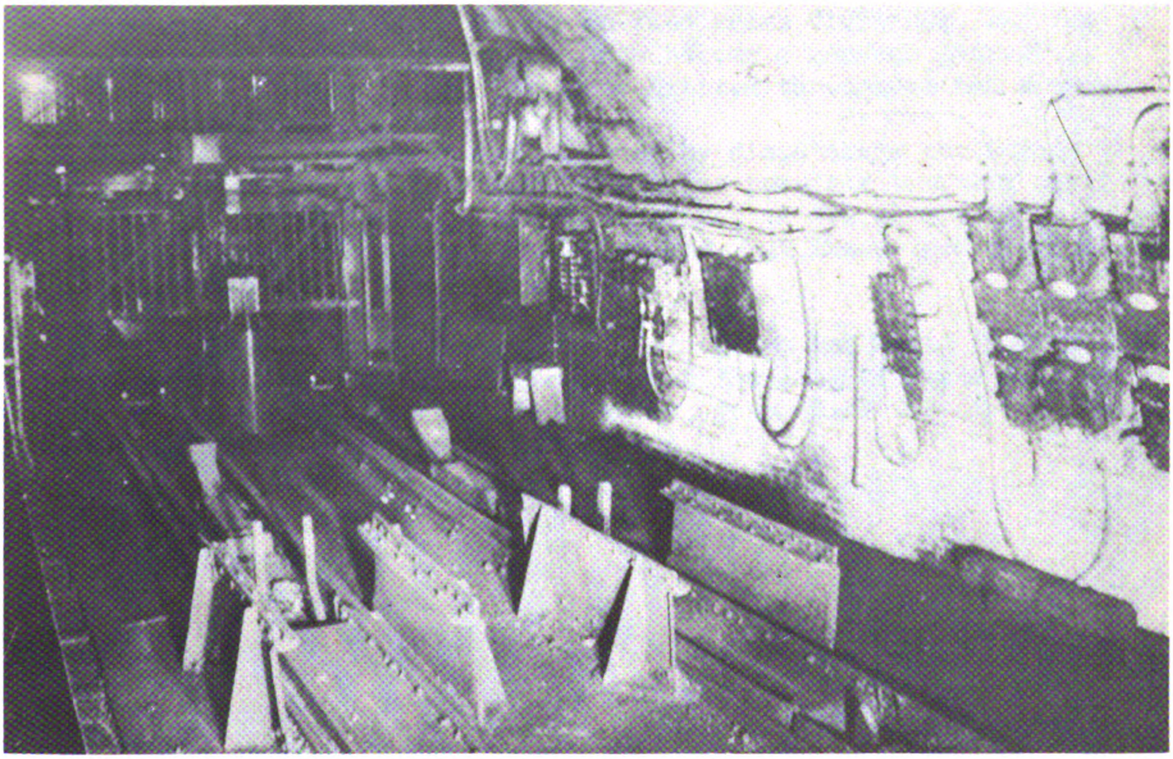

Figure 9. - Automatic cagers at shaft landing.

Flying switches are quite common, and cars are generally allowed to drift downgrade uncontrolled when it is necessary to replenish the supply at loading points.

Stopblocks and automatic cagers (fig. 9) are always placed at shaft landings, and a derailing device is used on inclined track, although underground slopes and planes seldom are found.

Diversion fences and warning lights and signs are mandatory where manways approach haulageways.

Trip lights were attached to the end car of all trains when available, but there was a severe shortage of these lights.

Very few man-trips, as such, are operated, but when men are transported, ordinary mine cars are used for that purpose. The trips are conducted in a very orderly manner, hauled at reduced speed, and supervised by an official. Trolley wires are not guarded at man-trip loading stations, but the wires are deenergized during loading and unloading. The pantograph-type trolley contact prohibits the use of trolley-wire guards, and all trolley wires were installed at least 6 feet above the rail in accordance with the mine law. Accident statistics showed only one electrocution in 20 years - a commendable record.

Another **common hazardous** practice is riding on chain, retarding, and shaker conveyors, especially at the working face, where side and head room are often very restricted. The profusion of supplies and coal as well as debris from the coal bed makes travel in face areas difficult, and the conveyor line, being the freest route, has become a general travelway. Riding on belts, however, is generally prohibited throughout the region.

Movement of all equipment was directed by dispatchers who worked at a station from which telephonic communication was possible to every section of the mine as well as to important surface points. A few block-signal systems were employed at sidetracks and passing points, but these were not numerous enough to be important.

In order to couple or disengage cars at shafts and avoid injuries to couplers because of the style of coupling and the lack of space between car ends, pits were provided under the track, from which the car coupler could perform his duties in relative safety.

Original from THE OHIO STATE UNIVERSITY